URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS
12-7A-5
Fire Resistive Standards for
DECKS AND OTHER HORIZONTAL ANCILLARY STRUCTURES

STATE FIRE MARSHAL

(a) ***Application.*** *The minimum design, construction and performance standards set forth herein for unloaded decks are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A.*

(b) Scope. *This standard determines the performance of decks (or other horizontal ancillary structures in close proximity to primary structures) when exposed to direct flames and brands. The under-deck flame exposure test is intended to determine the heat release rate (HRR) and degradation modes of deck or other horizontal boards when exposed to a burner flame simulating combustibles beneath a deck. The burning brand exposure test is intended to determine the degradation modes of deck or other horizontal boards when exposed to a burning brand on the upper surface.*

(c) Referenced document

1. *ASTM D4933. Guide for moisture conditioning of wood and wood-based materials*
2. *ASTM E108. Standard Test Methods for Fire Tests of Roof Coverings*
3. *California Building Code, Chapter 7A*

(d) Definitions*.*

1. Deck boards. *Horizontal members that constitute the exposed surface of the ancillary structure.*

2. Heat release rate. *The net rate of energy release as measured by oxygen depletion calorimetry*

(e) ***Test Assembly.***

1. Size*. The overall size of the test deck shall be 2 x 2 ft (610 x 610 mm) unless width variation of deck boards requires an increase in overall deck width (i.e., the direction of joists) in order to meet the overall dimensions. The length of individual deck boards shall be 2 ft (610 mm).*

2. Joists*. The deck is supported by two sets of 2 x 6 Douglas-fir joists, 28 in. (710 mm) long, and constructed with a 16-in. (406 mm) center-to-center spacing. The joists shall be conditioned to 6% equilibrium moisture content as per ASTM D4933. A comparable species that may be more commonly used for structural framing of decks in a given region can be substituted for Douglas-fir.*

3. Deck board spacing and fastening*. Edge-to-edge spacing is 3/16 in. (5 mm), with boards attached to the joists with 2-in. (50 mm) deck screws inserted into deck boards spaced 1.5 in. (38 mm) from the front and back edges of the deck boards. The front deck board shall be flush with the ends of the joists, and the rear deck board shall overhang the end of the joists by 1 in. (25 mm).*

i) Boards manufactured for tongue and groove edge connections are to be spaced as per the manufacturer's recommendation.

ii) Alternate fastening schedules can be used if specified by the deck board manufacturer

iii) If 2 x 6 deck boards are used, a total of 5 boards shall be used for each deck. Changing the board width could change the number of deck boards.

(f) Materials.

1. All deck board materials are to have cross-sectional dimensions equivalent to use in service.

2. Material tested must be representative of commercially available products

3. If solid wood deck boards are used, the species or lumber group shall be identified.

4. If the material is "plastic lumber" or other composites, the type and amounts of the plastic(s) and the wood-plastic ratio shall be determined.

5. All materials are to be conditioned to equilibrium to 6% EMC conditions prior to testing as specified in ASTM D4933.

PART A. Under-flame test

(a) ***Equipment***

1. Burner*. A 12 x 12 in. (300 x 300 mm) sand burner shall be used to provide an output of 80 ± 4 kW using a regulated propane gas source. Burner output can be determined from HRR or calculated from propane flow rate, temperature, and pressure.*

2. Oxygen depletion calorimeter. *The system includes a hood, associated ducting, and instrumentation to provide HRR data by oxygen depletion calorimetry.*

(b) ***Test system preparation (Figure 1)***

1. Deck support assembly. *Assembly that holds the test deck over the burner.*

2. Baffle panels and joist support. *Horizontal metal plates to support the deck joists along their full length, and also to confine burner flames to the underside of the deck boards located between the support joists.*

3. Back wall. *Ceramic fiber board or another noncombustible panel product for the back wall material. Total height of the back wall is 8 ft (2.4 m).*

4. Ledger board. *A 4-ft (1.2-m) long simulated 2 x 6 ledger board shall be constructed of layers of ceramic fiber board (or other noncombustible panel product) and attached to the wall at a height slightly below the overhang of the rear deck board of the test deck*

(c) ***Conduct of Tests.***

1. ***Airflow****. The test is conducted under conditions of ambient airflow.*
2. ***Number of tests****. Conduct the test on three replicate assemblies*
3. ***Burner output verification.*** *Without a deck in the apparatus, set the output of the burner to 80 ± 4 kW. Conduct a verification run of 3 min to assure the heat release rate, then turn off the burner.*
4. ***Measurement of heat release rate.*** *HRR is measured during the tests with a properly calibrated oxygen depletion calorimeter. Since HRR is typically a post-test analysis, this criterion for Acceptance may be determined at the end of the test.*
5. ***Burner configuration****. Center the burner directly under the middle deck board, midway between the joists. The distance from the top of the burner to the bottom of the deck boards shall be 27 in. (690 mm)*
6. ***Procedure****.*

   i) Ignite the burner, controlling for a constant 80 ± 4 kW output.

   ii) Continue the exposure for a 3 min period, Extinguish the burner.

   iii) Continue observation for an additional 40 min or until all combustion has ceased. The test shall be terminated immediately if flaming combustion accelerates uncontrollably (runaway combustion) or structural failure of any deck board occurs.
7. ***Observations****. Note physical changes of the deck boards during the test, including structural failure of any deck board, location of flaming and glowing ignition, and loss of material (i.e, flaming drops of particles falling from the deck). It is desirable to capture the entire test with a video recorder to allow review the details of performance.*

(d) ***Report.*** *The report shall include a description of the deck board material and the time of any degradation (peak heat release rate, structural failure, flaming drops or particles falling from the deck) during the test.*

(e) Conditions of Acceptance. *Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.*

1. Peak heat release rate of less than or equal to 25 kW/ft^2 (2.3 kW/m^2)

2. Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 40-min observation period.

3. Absence of structural failure of any deck board.

4. Absence of falling particles that are still burning when reaching the burner or floor.

PART B. Burning brand exposure

(a) Equipment

1. Wind tunnel*. The wind tunnel shall have the capability of providing 12 mph (5.4 m/s) airflow over the deck assembly*

2. ***Anemometer****. Device for measuring airflow across the deck.*

3. ***Burner****. Gas-fueled burner for brand ignition.*

(b) Test system preparation. *(Figure 2)****.*** *The ASTM E108 "A" brand roof test apparatus is to be used, with the following modifications:*

1. ***Deck support****. The deck shall be supported horizontally with the center 60 in. (150 mm) from the front opening of the wind tunnel and the joists parallel to the airflow and resting on two transverse metal supports. The top surfaces of these supports, no more than 3 in. (75 mm) wide, are at the same height as the floor of the wind tunnel.*

2. ***Fragments****. Burning fragments shall be free to fall to the floor of the room.*

(c) Conduct of Tests

1. ***Number of tests****. Conduct the test on three replicate assemblies*

2. Procedure. *Adhere to ASTM E108 "Standard Test Methods for Fire Tests of Roof Coverings" (burning brand test, "A" brand), with apparatus modified as described above in "Test system preparation" and the following procedure:*

i) The air velocity shall be calibrated using the 60-in. (1.5-m) framework spacing, with the deck positioned 60 in. (1.5 m) from the front opening of the wind tunnel. All other measurement details shall be followed as specified in sections 4.4.2, 4.4.3, and 4.4.4 of ASTM E 108. Although ASTM E 108 specifies calibration to be conducted with the 33-in. (840-mm) framework spacing used for the intermittent flame test set up, tests have shown that at the nominal 12 mph setting, there was not difference in measured velocity between the 33- and 60-in. framework spacing.

ii) Ignite the "A" brands as specified in Section 9.4 of ASTM E 108, with the exception of the ignition sequence:

(1) Each 12- x 12-in. (300- x 300-mm) face for 30 s

(2) Each 2.25- x 12-in. (57- x 300-mm) edge for 30 s

iii) Center the burning brand laterally on the deck with the front edge 2.5 in. (64 mm) from the entering air edge of the deck.

iv) Continue the exposure for a 40-min period or until all combustion of the deck boards ceases or a board collapses.

*v) Heat Release Rate is not monitored because of the impracticability with the specified airflow****.***

3. Observations*. Note physical changes of the deck boards during the test, including deformation from the horizontal plane, location of flaming and glowing combustion, and loss of material (i.e, flaming drops of particles falling from the deck). It is desirable to capture the entire test with a video recorder to allow review of the details of performance.*

(d). Report. *The report shall include description of the deck board material, and the time of any degradation (accelerated combustion, board collapse, flaming drops or particles falling from the deck.*

(e). Conditions of Acceptance. *Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.*

1. Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 40-min observation period.

2. Absence of structural failure of any deck board.3. Absence of falling particles that are still burning when reaching the burner or floor.

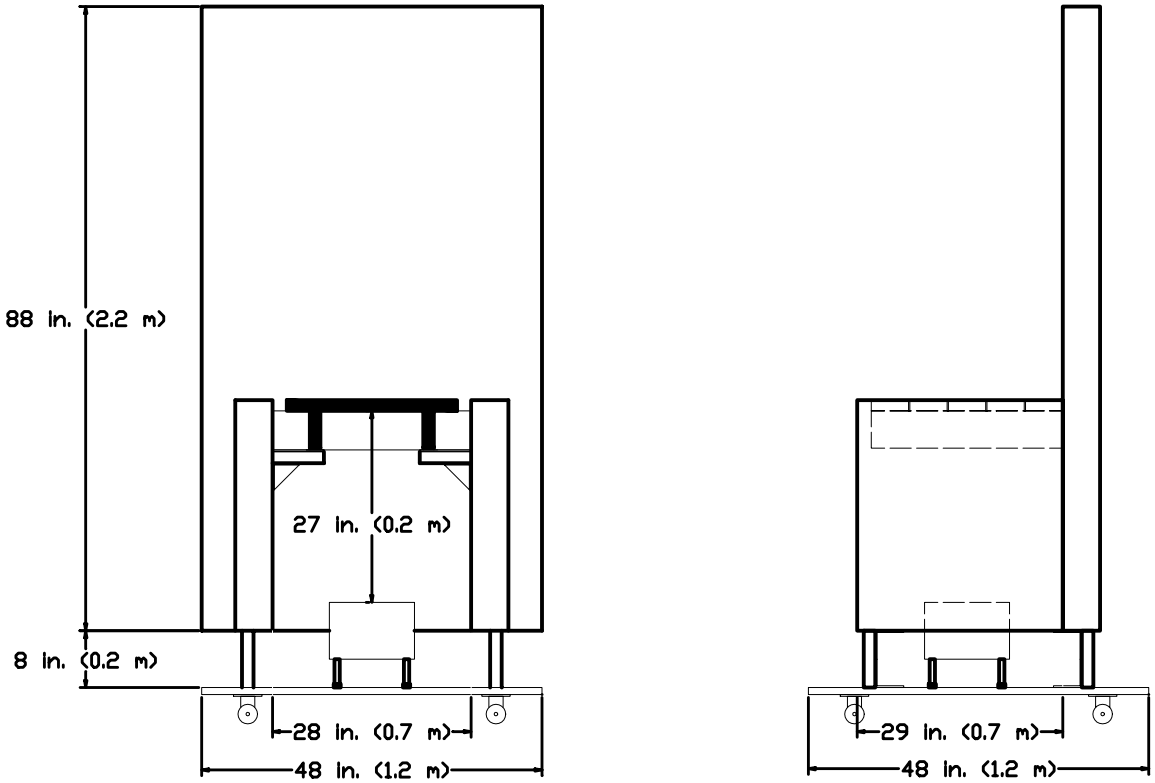

Figure 1. Deck Test Assembly (Under–flame)

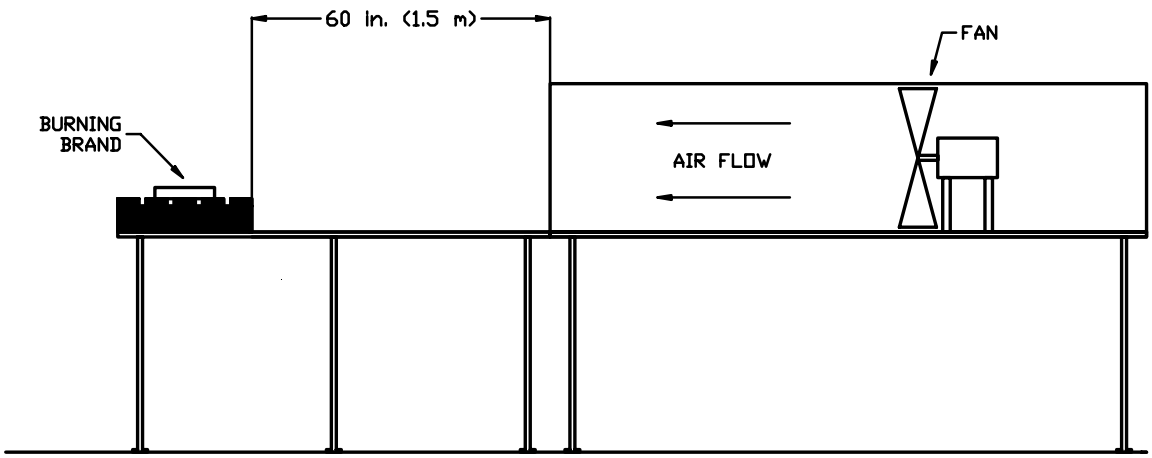

Figure 2. Deck Test Assembly (Burning-Brand)

COMMENTARY: DECKING

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to "certify" materials and/or assemblies, but to provide guidance in the development of the test protocols and for the "conditions of acceptance." Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire. The major concern about the ignition of decking is the hazard that it presents to the habitable structure. For example, most decks, porches, patios, and landings are directly adjacent (and usually attached) to the structure. Also, decks in particular tend to be above slopes having hazardous vegetation.

Most decking is configured so that it is threatened by two potential sources of ignition: brands and under-flames, with the following scenario:

1. A brand lands on a deck, causing glowing combustion at the opening between boards, and then to flaming combustion. The flames impinge on a sliding door, breaking the glass, and permitting penetration into the structure, or the flames impinge on combustible siding, causing penetration through the siding or at some other vulnerable point.

2. A brand is blown under a deck and on combustible material. The material ignites and the decking goes into flaming combustion. The flames impinge on a sliding door, breaking the glass, and permitting penetration into the structure, the flames impinge on combustible siding, causing penetration through the siding or at some other vulnerable point. Alternatively, the initial ignition could have been flame contact of the combustibles by a surface fire, but the outcome (penetration through a sliding door, siding combustion, etc.) would be the same.

In both scenarios, the outcome is the same–the deck goes into flaming combustion and the fire penetrates the structure. Decks can also present a hazard to other structures from flaming debris (brands) developed from the fire. Another often-unrecognized hazard is the loss of mechanical

integrity of the deck boards after combustion that can present a hazard to anyone walking on the deck.

Deck assembly. A key decision was the construction and size of the deck. After under-fire testing various sizes from "pallet size" about 4 x 4 ft (1.2 x 1.2 m), it was found that the minimum size for reproducibility was 2 x 2 ft (610 x 610 mm), with 2 x 6 joists spaced 16-in. (406-mm) on center (a common joist spacing for decks). Deck board spacing was 3/16 in. (5 mm). There is a key relationship between deck and burner size, in that the burner must be small enough to not impact the deck edges. The 12- x 12-in. (300- x 300-mm) burner concentrated its direct energy in an area slightly larger than the burner size. For combustible materials, there is also horizontal flamespread on the underside that is largely confined to the space between the joists.

Development of the Test Protocol. Since there are two scenarios for ignition, two tests were developed: (1) decking under-flame and (2) top-deck flaming brand. The "under-flame" deck assembly was supported over a 12- x 12-in. (300- x 300-mm) propane burner, and abutted to a 1.8-m gypsum board wall. The under-decking test was modeled after Babrauskas (1995) and Lee (1985) by using an 80-kW fire (equivalent to about 1 kg of paper trash). The under-flame test included a measurement of heat release rate to determine if that would be a useful criterion for determining accelerated combustion. In order to have impingement of the flame tip on the underside of the deck boards a spacing of 27 in. (690 mm) from top of burner to bottom of decking was chosen. Preliminary tests were conducted to determine the length of time of exposure to flames, and a 3-min exposure was consistent for the 1-kg paper scenario, and produced the best sensitivity in decking performance. The top-deck flaming brand test was modeled after a similar brand test for roofs as described in ASTM E108, also using 12 mph airflow.

Tests

Materials. The deck tests included 15 commercial deckboard materials (wood, wood/plastic, and all-plastic) that were chosen to be representative of the range of more than 20 products available on the market in early 2001. Selection of products was based on material composition and cross-section form. The deck materials were purchased from retail sources between March and May 2001. The boards were cut into 610 mm (2 ft) lengths, and five pieces, taken from different full-length boards to minimize effects of any board-to-board variability, were used to make each test deck.

Under-flame tests were conducted on the deck materials shown in Table 1. Since many decks in California are constructed of nominal 2-in. (38-mm) deckheart-grade redwood, this material served as a reference in an approach similar to that of ASTM E 84, Standard test method for surface burning characteristics of building materials. Where E 84 uses red oak conditioned to 12% moisture content (MC), the deck materials were conditioned to 6% MC in order to simulate the very low equilibrium MC conditions of fire weather. Since a number of new plastic and "plastic-lumber" products were appearing on the market, representative materials were acquired from retail outlets. Each of these was analyzed (Table 1) since variation in composition could affect their performance. Based on the results of the under-flame tests, 11 of the 15 materials were selected for the brand test.

Results. There were three major events that we observed for a wide range of deck boards: accelerated (runaway) combustion, dripping or dropping of flaming combustibles, and collapse of deck boards. Since some of these events occurred long after the 3-min under-flame and secession of the brand exposures, the total test time was set at 40 min to ascertain that all events had been completed.

Table 2 gives observations over time for the under-flame test. The last five materials in the list had no negative events. Of the other ten materials, all but Trex would have failed mechanically (including unreinforced Bedford and Ecoboard). Two of the decking materials (Eon and Maxituf) had runaway combustion within the 3-min flame exposure and were extinguished at that time (but would have also collapsed). Evernew (the only one made of polyvinyl chloride) did not burn, but vaporized in the area of the burner. Both of the deckboard materials with a "channeled" form on the underside (ChoiceDek and TimberTech) had early degradation effects, presumably from the increased surface area on the underside. The dripping of flammable material to the burner or the floor was prevalent with most of the materials as a consequence of the plastic formulations.

In Table 3, results for the "A" brand test are presented. As anticipated, this type of exposure delayed the dripping and collapse shown in Table 2. Also, only one material had accelerated combustion (Ecoboard) and its performance was similar to the under-flame test. Three materials performed without negative events in both exposures (solid Weatherbest, Redwood, reinforced Bedford) and two had similar performances (Ecoboard, Nexwood). The remaining 10 had differing events between the tests.
The material with the highest wood fraction (SmartDeck) appeared to lack the ability to support its own weight in long-term exposure. All of the deckboard materials with a "channeled" form on the underside (Eon, ChoiceDek, and TimberTech) had early degradation effects in the under-deck fire tests, presumably from the increased surface area. In the burning brand tests, this early degradation was not seen. On the other hand, all of the "hollow" construction products, which generally performed well in the under-deck tests, exhibited board collapse within the 40-min test period in the burning brand tests. This was no doubt due to the reduced thickness of the upper surface, since burn-through occurred in the hollow core areas, where flaming was sustained until the board collapsed. Although the polyvinyl chloride sample, EverNew, collapsed very quickly in the under-deck fire test, it did not exhibit sustained combustion, as did most of the polyethylene-based products. Eon, which appeared to be ABS [poly(α-methyl stryene)], underwent very rapid and intense runaway combustion, as did the all-polyethylene Maxituf. Eon caused the release of corrosive gases which degraded all instrumentation in the fire lab.

Table 4 gives the Peak Heat Release Rate for the under-flame tests (because of the 12-mph airflow, HRR measurements cannot be made for the "A" brand tests). In Table 2, the notation of acceleration of heat release was from visual judgment, since HRR is determined post-test. However, it is important that a quantitative measure of HRR be used, since visual judgment can very arbitrary. Therefore, a cut-off point must be chosen. In comparing Tables 2 and 4, it is apparent that the visually-observed accelerated combustion was noted for all runs from Ecoboard to Eon, and none from reinforced Bedford to Rhinodeck. Only Nexwood was in question since one of three tests had accelerated combustion. Therefore, the threshold for detection of accelerated combustion was established at 100 kW or 25 kW/ft^2 (2.3 kW/m^2).

Comments. All tests were videotaped and most had still photos taken. The tapes were used to verify direct observations. The assemblies were tested by the end of June 2001 and therefore the composition of the synthetic materials reflected those manufactured by that date. Since the composition of most of the deckboards is proprietary, the results in Tables 2 and 3 apply to the analysis shown in Table 1, and not to the particular trade name. Thus the user cannot assume that a newly-purchased product would necessarily have the same performance as the one of the same name tested, unless the manufacturer provides assurance that the product formulation has not changed. Most materials had some combustion that was accelerated by the open front edge of the deck assembly during the under-flame test. In general, this had little effect on the results, but was helpful to understand the effect of under-deck flamespread to the edge of a deck. For the most part, the ends of the deckboards were shielded by joists, however, fire occasionally spread under or around the joists. In this case, negative effects that could affect the degradation criteria were discounted. On the other hand, ends of deck boards do exist, and the exposure of core material in some products could make them more vulnerable to degradation. The common 3/16 in. (5 mm) gap spacing is used to drain standing water from decks and also permit the joist-deck board interface to properly ventilate. However, virtually all products developed their initial flaming state by burner flames that penetrated through the deckboards. This becomes a bootstrapping process where the facing edges are mutually heated to sustain combustion. The ratio of low- to high-density polyethylene did not appear to have an effect on fire performance. It was anticipated that high ratios would not have performed as well as low, but this was not observed.

Conditions of acceptance. Based on the tests, the acceptance criteria listed in Standard SFM-5 were considered appropriate for each of the two tests. Because of the substantial difference between the tests, both are necessary for acceptance in Very High Fire Hazard Zones.

References.

1. Babrauskas, V., *Burning Rates*, Section 2, Chapter 1 in SFPE Handbook of Fire Protection Engineering, 2nd edition, (P.J. DiNenno, editor-in-chief), Society of Fire Protection Engineers, Boston (1995), pp 2-1 to 2-15.

2. Lee, B. T., Heat Release Rate Characteristics of Some Combustible Fuel Sources in Nuclear Power Plants, NBSIR 85-3195, National Bureau of Standards, Washington (1985).

Table 1. Deckboard Materials & Properties

Product	Form	Plastic Type	Density	Composition (%)			LDPE*** (%)
				Wood Fiber*	Plastic**	Ash	
Wood - Plastic Composites*							
ChoiceDek	channeled	polyethylene	0.91	48	50	2	44
Nexwood	hollow	polyethylene	1.17	46	42	12	11
Rhino Deck	solid	polyethylene	1.13	64	35	1	1
SmartDeck	solid	polyethylene	0.10	65	33	2	23
TimberTech	channeled	polyethylene	1.22	48	37	15	7
Trex	solid	polyethylene	0.92	53	46	1	38
WeatherBest	hollow	polyethylene	0.20	60	33	7	20
WeatherBest	solid	polyethylene	1.20	61	31	8	0
Plastic (pure or fiberglass reinforced)							
Bedford (reinforced)		solid polyethylene	1.06	0	85	15	12
Bedford (unreinforced)		solid polyethylene	0.97	0	97	3	0
Ecoboard	solid	polyethylene	0.85	0	99	1	10
Eon	channeled	ABS?	0.80	0	100	0	-
EverNew	hollow	polyvinyl chloride	1.44	0	90	10	-
Maxituf	solid	polyethylene	0.94	0	100	0	0
Wood							
Redwood	solid	--	0.40	100	0	0	-

* Percent of sample dissolved in acid digestion, corrected for acid-soluble ash. Pure or fiberglass-reinforced plastics not subjected to acid digestion procedure.
** For wood-plastic composites, "plastic" is the fraction insoluble in acid digestion, corrected for acid-insoluble ash.
*** For polyethylene-based products, %LDPE = LDPE/(LDPE + HDPE)*100. By pyrolysis-GC.

Table 2. Under-flame test, 3 min at 80 kW

Time (min)	0	5	10	15	20	25	30	35	40
Eon	DA								
Maxituf	DA								
Evernew	M								
TimberTech	D	A	M						
ChoiceDek	D		A	M					
Nexwood			D	M					
Bedford (unreinforced)	D			A					
Ecoboard	D				A				
Trex					D				
Rhino Deck					M				

NO DEGRADATION EFFECTS

Smart Deck

Weatherbest (solid)

Weatherbest (hollow)

Bedford (reinforced)

Redwood

D = dripping flammable material
A = accelerated (runaway) combustion
M = mechanical collapse or one or more boards

Table 3. Burning brand test ("A" brand)

Time (min)	0	5	10	15	20	25	30	35	40
Rhino Deck				D					
Ecoboard		D			A				
Nexwood			D			M			
Trex				D			M		
Smart Deck						D		M	
Weatherbest (hollow)									M
Bedford (unreinforced)	D								

NO DEGRADATION EFFECTS

Bedford (reinforced)
Weatherbest (solid)
Redwood
TimberTech

D = dripping flammable material
A = accelerated (runaway) combustion
M = mechanical collapse or one or more boards

Table 4. Peak Heat Release Rate for deck assemblies exposed to 80 kW under-flame test. Average values for three tests unless otherwise noted.

Deck Material	HRR (kW)
Bedford (reinforced)	<10
Weatherbest (hollow)	<10*
Weatherbest (solid)	<10
Redwood	12
SmartDeck	15
Trex	29
RhinoDeck	90
Nexwood	165*
Ecoboard	203***
ChoiceDek	45***
TimberTech	394***
Bedford (unreinforced)	416***
Maxituf	695** (only 2 runs)
Eon	1055* (only 1 run)

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* Number of tests with accelerated heat release (runaway).